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(54) **ZOOM LENS ASSEMBLY SOUNDLESS IN OPERATION, CAMERA MODULE HAVING ZOOM LENS ASSEMBLY, AND ELECTRONIC DEVICE HAVING CAMERA MODULE**

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**H04N 23/55** (2023.01)

(52) **U.S. Cl.**  
CPC ..... **H04N 23/69** (2023.01); **G02B 7/09** (2013.01); **H04N 23/55** (2023.01)

(58) **Field of Classification Search**  
CPC ..... H04N 23/55; H04N 23/57; H04N 23/69; G02B 7/09  
See application file for complete search history.

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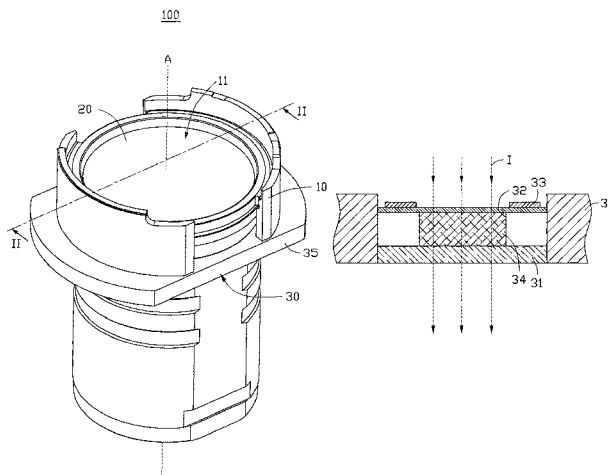
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(57) **ABSTRACT**

A zoom lens assembly for periscope use which is effectively soundless in operation includes a lens barrel defined with a through hole, a plurality of optical lenses disposed within the through hole, and a focusing member disposed between any two of the plurality of optical lenses. The focusing member in a camera module includes a bottom plate, a cover plate, a piezoelectric element, and a variable transparent body. The variable transparent body is between the bottom plate and the cover plate, the piezoelectric element is disposed on a surface of the cover plate that faces away from the variable transparent body. Electricity fed to the piezoelectric element causes movement of the element which deforms the variable transparent body and changes the focal length of the camera module.

**17 Claims, 7 Drawing Sheets**



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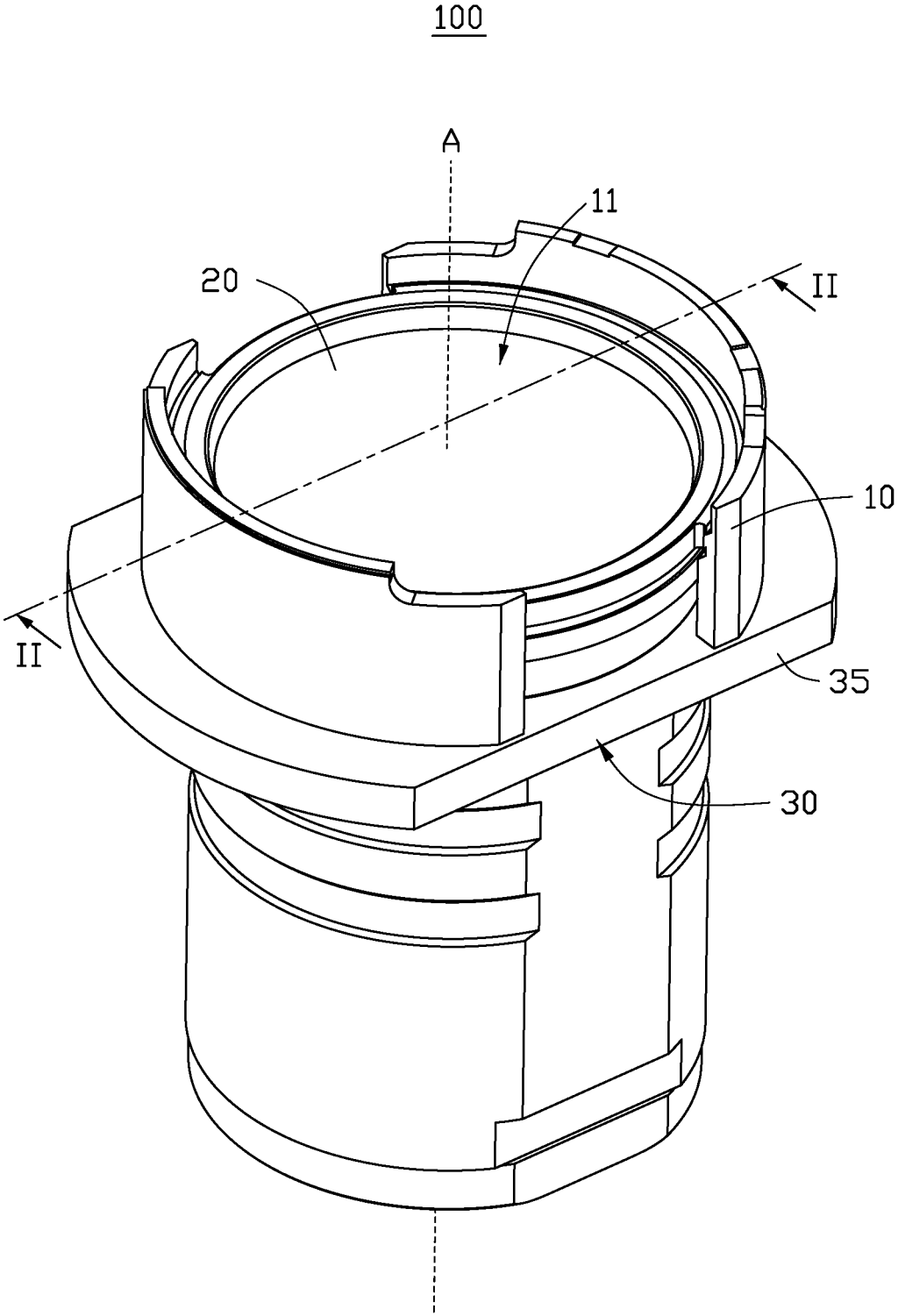


FIG. 1

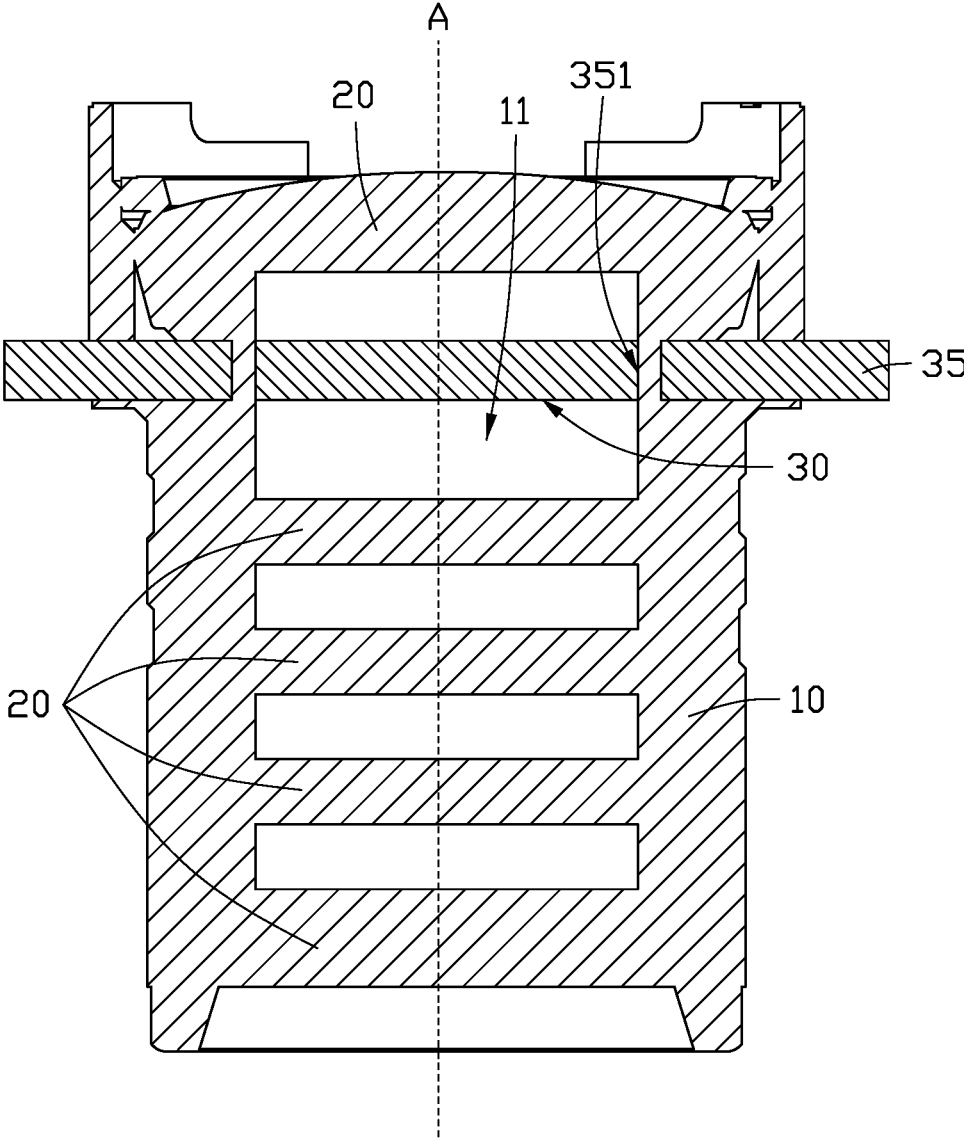


FIG. 2

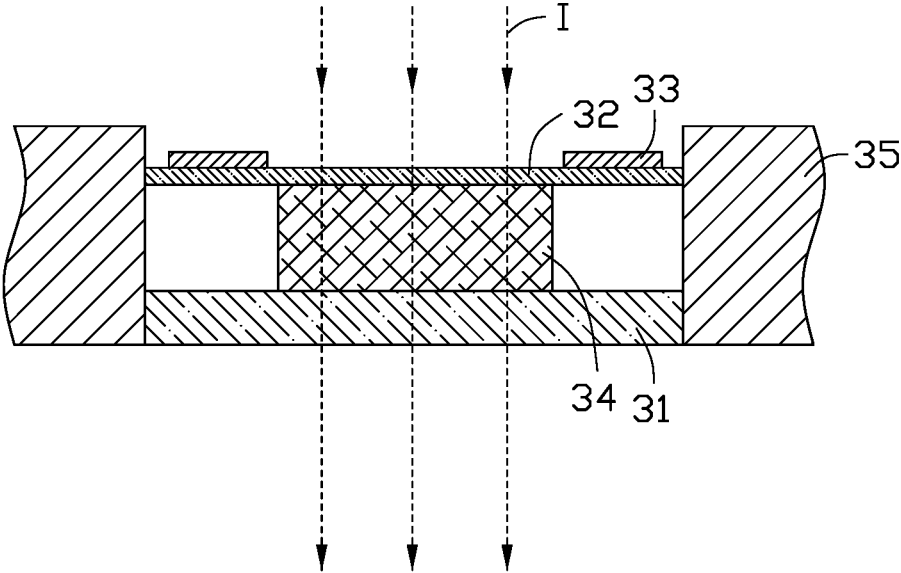


FIG. 3A

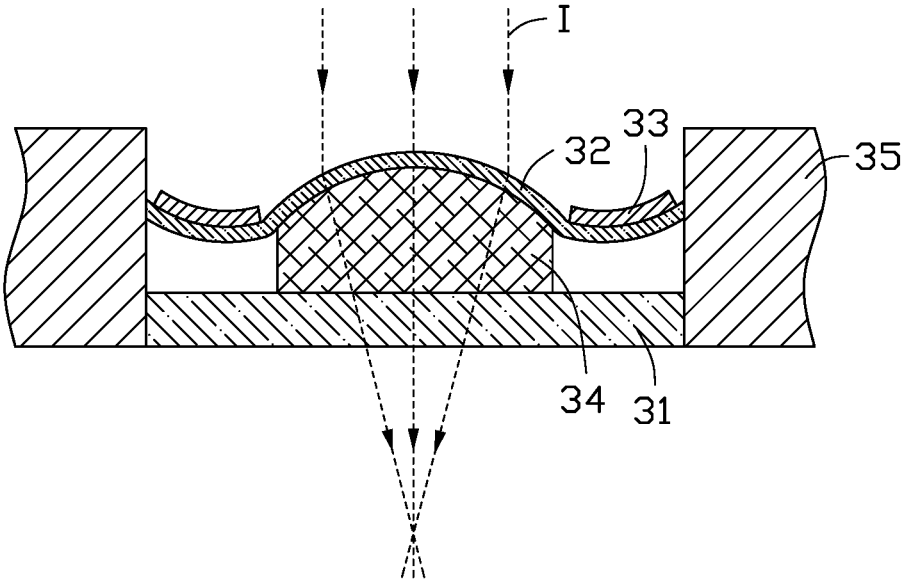


FIG. 3B

200

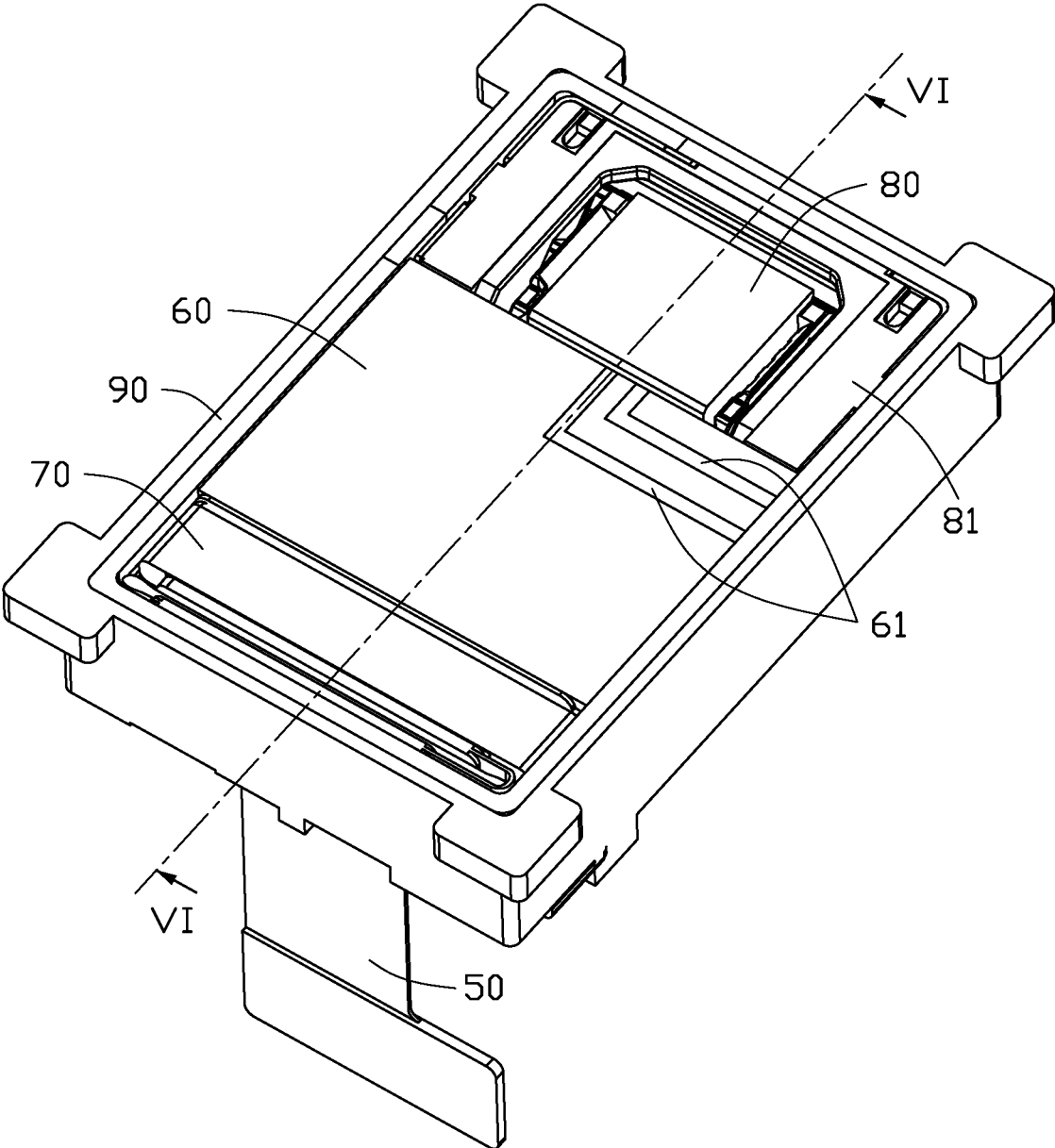


FIG. 4

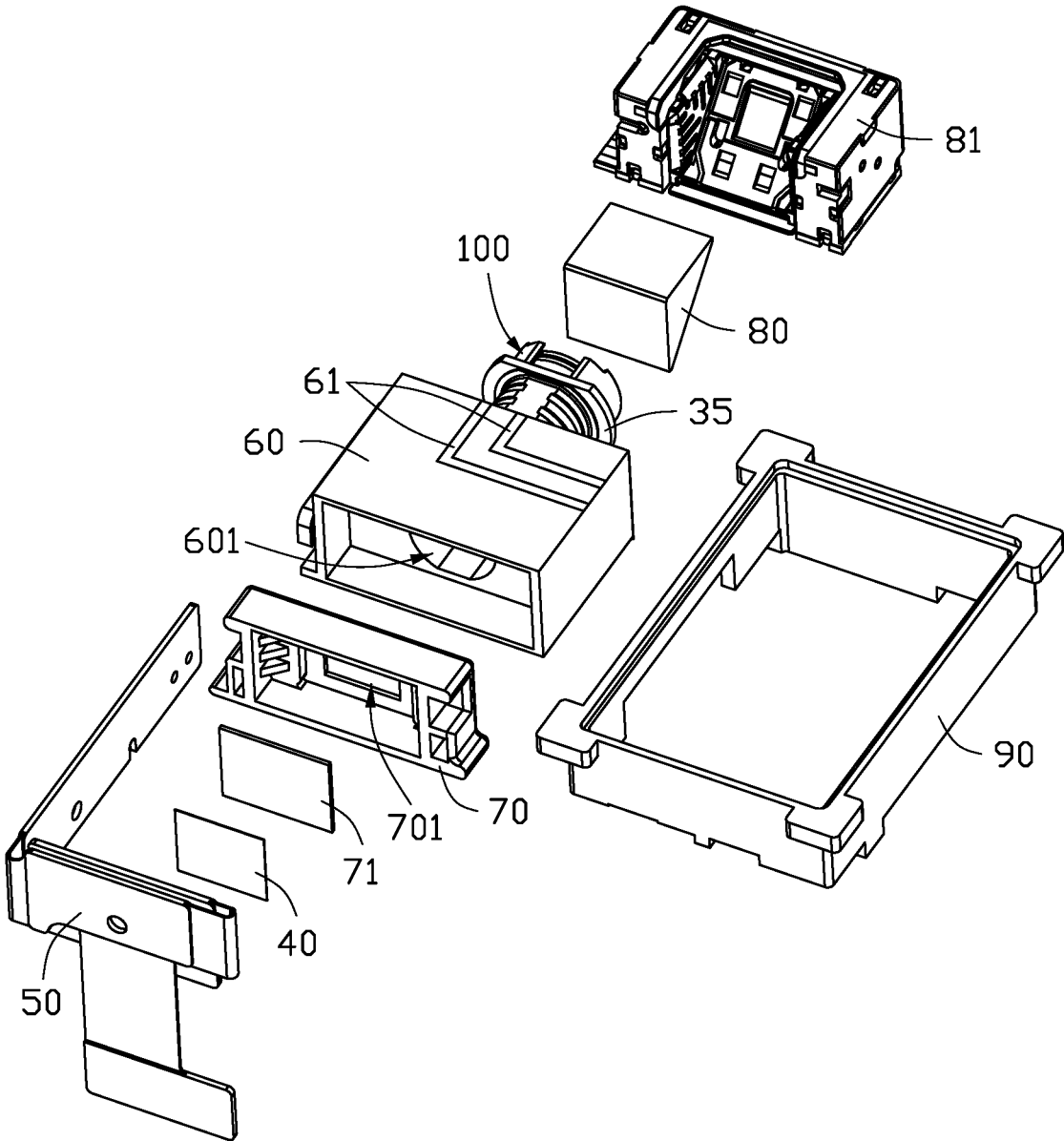


FIG. 5

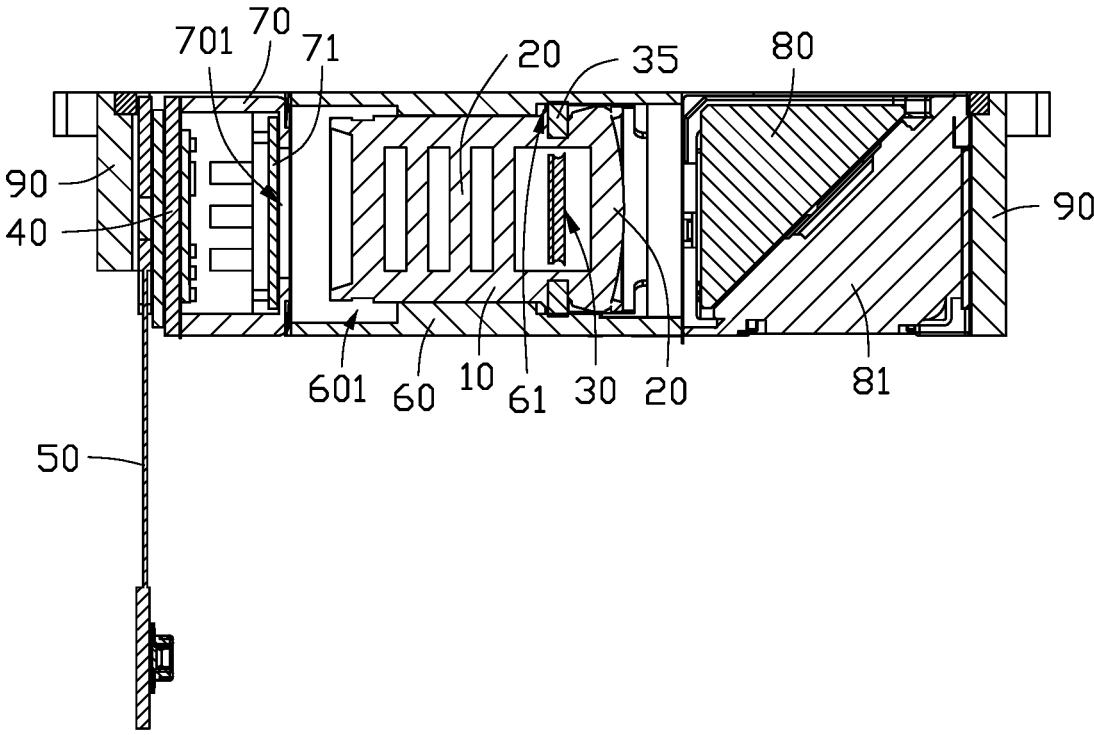


FIG. 6

300

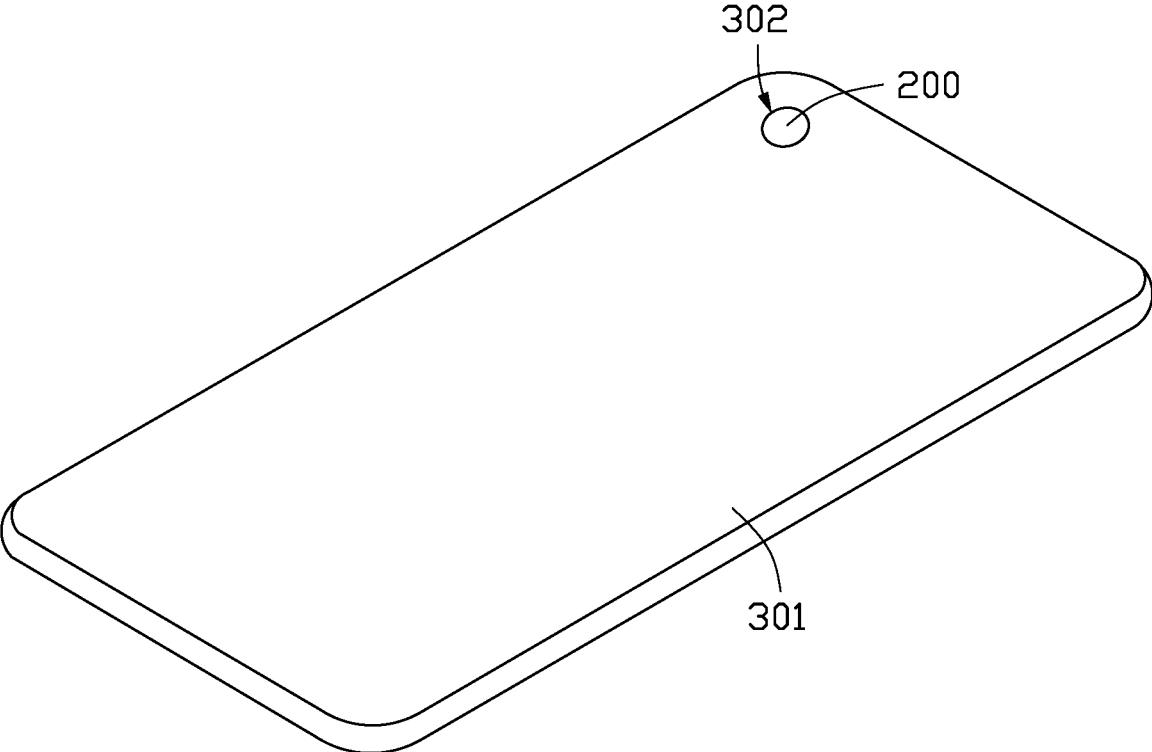


FIG. 7

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**ZOOM LENS ASSEMBLY SOUNDLESS IN  
OPERATION, CAMERA MODULE HAVING  
ZOOM LENS ASSEMBLY, AND  
ELECTRONIC DEVICE HAVING CAMERA  
MODULE**

FIELD

The subject matter herein generally relates to image capturing, and more particularly, to a zoom lens assembly soundless in operation, a camera module having the zoom lens assembly, and an electronic device having the camera module.

BACKGROUND

A camera module with auto-focusing function may include a prime lens and a voice coil motor. The voice coil motor drives the prime lens to move, thereby changing a position of the prime lens with respect to an image sensor. However, movements of the prime lens cause noise which is undesirable, for example, when photographing wildlife or in a security situation where any noise may activate a sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

Implementations of the present technology will now be described, by way of example only, with reference to the attached figures.

FIG. 1 is a diagrammatic view of a zoom lens assembly according to an embodiment of the present disclosure.

FIG. 2 is a cross-sectional view along line II-II of FIG. 1.

FIG. 3A is a focusing member of the zoom lens assembly of FIG. 1.

FIG. 3B is similar to FIG. 3A, but showing the focusing member in another state.

FIG. 4 is a diagrammatic view of a camera module with the zoom lens assembly of FIG. 1 according to an embodiment of the present disclosure.

FIG. 5 is an exploded view of the camera module of FIG. 4.

FIG. 6 is a cross-sectional view along line V-V of FIG. 4.

FIG. 7 is a diagrammatic view of an electronic device according to an embodiment of the present disclosure

DETAILED DESCRIPTION

It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale, and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

The disclosure is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings, in which like references indicate similar elements. It should be noted that references to “an” or “one” embodi-

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ment in this disclosure are not necessarily to the same embodiment, and such references mean “at least one.”

The term “comprising,” when utilized, means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

Referring to FIGS. 1 and 2, an embodiment of a zoom lens assembly **100** entirely silent in operation is provided. The zoom lens assembly **100** includes a lens barrel **10**, a plurality of optical lenses **20**, and a focusing member **30**.

The lens barrel **10** is cylindrical. The lens barrel **10** defines a through hole **11**. The through hole **11** has a central axis A. The optical lenses **20** are arranged in the through hole **11** along the central axis A. The focusing member **30** is disposed between two adjacent optical lenses **20**.

Referring to FIGS. 3A and 3B, the focusing member **30** has piezoelectric properties. The focusing member **30** includes a bottom plate **31**, a cover plate **32**, a piezoelectric element **33**, and a variable transparent body **34**. The variable transparent body **34** is disposed between the bottom plate **31** and the cover plate **32**. The piezoelectric element **33** is disposed on a surface of the cover plate **32** opposite to the variable transparent body **34**. The piezoelectric element **33** is staggered from the variable transparent body **34**, so that when an electric voltage is applied to the piezoelectric element **33**, an end of variable transparent body **34** will start to deform firstly, making the focusing member **30** to become a convex lens. Thereby, changing the focal length of the focusing member **30**. In at least one embodiment, the piezoelectric element **33** is made of Lead Zirconate Titanate (chemical formula of  $Pb[Zr_xTi_{1-x}]O_3$ , wherein  $0 \leq x \leq 1$ ). The Lead Zirconate Titanate changes its shape when the electric voltage is applied thereto. The variable transparent body **34** is made of polydimethylsiloxane (PDMS). The bottom plate **31** and the cover plate **32** are glass membranes. The thickness of the bottom plate **31** is greater than the thickness of the cover plate **32**, so that the bottom plate **31** can support the variable transparent body **34** and the cover plate **32**.

The cover plate **32** is flat in its original state. When incoming light beams “I” travel through the cover plate **32**, the variable transparent body **34**, and the bottom plate **32**, the direction of light beams “I” is not changed. The charged piezoelectric element **33** applying mechanical force to the cover plate **32** causes the cover plate **32** to become curved, which deforms the variable transparent body **34**. Thereby, the direction of light beams “I” travelling through the cover plate **32**, the variable transparent body **34**, and the bottom plate **32**, is changed, thereby changing a focal length of the zoom lens assembly **100**.

With the above configuration, auto-focusing can be achieved by the piezoelectric element **33** in applying mechanical force on the variable transparent body **34**. The auto-focusing process is thus to all intents and purposes silent in operation. Meanwhile, because the focusing member **30** is embedded inside the lens barrel **10**, the integrity of the zoom lens assembly **100** is improved, which is beneficial for miniaturization of the zoom lens assembly **100**.

Referring to FIG. 2, in this embodiment, there are five optical lenses **20**, four of these being disposed on one side of the focusing member **30**, and the remaining optical lens **20** is disposed on opposite side of the focusing member **30**.

Referring to FIGS. 1 and 2, in this embodiment, the focusing member **30** further includes a conductive plate **35**. The conductive plate **35** defines an aperture **351**. A portion of the conductive plate **35** is embedded in the lens barrel **10**, and another portion of the conductive plate **35** protrudes from the lens barrel **10**. The portion of the conductive plate

**35** embedded in the lens barrel **10** defines the aperture **351**. The piezoelectric element **33** is electrically connected to the conductive plate **35**. The bottom plate **31**, the cover plate **32**, and the variable transparent body **34** are disposed within the aperture **351**. An edge of the bottom plate **31**, an edge of the cover plate **32**, and an edge of the variable transparent body **34** resist against an inner wall of the aperture **351**.

In at least one embodiment, the conductive plate **35** is made of metal. The lens barrel **10** is made of plastic. The conductive plate **35** and the lens barrel **10** are integrally formed.

Referring to FIG. 4, an embodiment of a camera module **200** is provided. The camera module **200** includes a sensor **40**, a circuit board **50**, and the zoom lens assembly **100**. The sensor **40** is connected to the circuit board **50**. The sensor **40** faces the through hole **11**. The sensor **40** may be a charge coupled device (CCD) or a complementary metal-oxide semiconductor (CMOS). The circuit board **50** may be a rigid board, a flexible board, or a rigid-flex board. The conductive plate **35** is connected to the circuit board **50**.

Referring to FIGS. 5 and 6, in this embodiment, the camera module **200** further includes a sleeve **60** and a conductive wiring **61**. The sleeve **60** defines a first receiving hole **601**. The zoom lens assembly **100** is disposed within the first receiving hole **601**. First end of each of the conductive wiring **61** is connected to the inner wall of the first receiving hole **601** and electrically connected to the conductive plate **35**. Second end of each of the conductive wiring **61** is connected to the outer wall of the first receiving hole **601** and electrically connected to the circuit board **50**. In this embodiment, the sleeve **60** and the conductive wiring **61** are formed by Direct Laser Sintering (DLS).

Referring to FIGS. 5 and 6, in this embodiment, the camera module **200** further includes a base **70** and an optical filter **71**. The base **70** defines a second receiving hole **701**. The optical filter **71** is disposed with the second receiving hole **701**. The base **70** is configured between the circuit board **50** and the sleeve **60**, the second receiving hole **701** faces the first receiving hole **601**, the optical filter **71** faces the sensor **40** and the zoom lens assembly **100**. The optical filter **71** may be an infrared cutout filter.

Referring to FIGS. 5 and 6, in this embodiment, the camera module **200** further includes a reflecting member **80** and an actuator **81**. The reflecting member **80** is disposed on an end of the sleeve **60** opposites to the base **70**. The actuator **81** is mechanically connected to the reflecting member **80**. The actuator **81** is used for adjusting direction of the light passing through the reflecting member **80**, so that the light can be parallel to the central axis A. In this embodiment, the reflecting member **80** may be a prism or a mirror. The actuator **81** can be a voice coil motor. Thereby, making the camera module **200** to be a periscope-type zoom camera module.

Referring to FIGS. 5 and 6, in this embodiment, the camera module **200** further includes an outer frame **90**. The reflecting member **80**, the actuator **81**, the circuit board **50**, the sleeve **60**, and the zoom lens assembly **100** are disposed within the outer frame **90**.

Referring to FIG. 7, an embodiment of an electronic device **300** is provided. The electronic device **300** includes a casing **301** and the camera module **200** disposed within the casing. The casing **301** defines an opening **302**. A portion of the camera module **200** is exposed from the opening **302**. Particularly, the electronic device **300** may be a cell phone, a notebook, a smartphone, an IPAD, or any other equipment with imaging function.

It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A zoom lens assembly comprising:  
a lens barrel defining a through hole;

a plurality of optical lenses disposed in the through hole;  
and

a focusing member disposed between adjacent two of the plurality of optical lenses;

wherein the focusing member comprises a bottom plate, a cover plate, a piezoelectric element,

a variable transparent body, and a conductive plate, the variable transparent body is disposed between the bottom plate and the cover plate, the piezoelectric element is disposed on a surface of the cover plate facing away from the variable transparent body, the piezoelectric element is staggered from the variable transparent body, so that when an electric voltage is applied to the piezoelectric element, an end of variable transparent body start to deform firstly, the conductive plate is connected to the piezoelectric element, the conductive plate defines an aperture, the bottom plate, the cover plate, and the variable transparent body are disposed in the aperture, the conductive plate and the lens barrel are integrally formed.

2. The zoom lens assembly of claim 1, wherein the conductive plate is partially embedded in the lens barrel.

3. The zoom lens assembly of claim 1, wherein the piezoelectric element is made of Lead Zirconate Titanate, and the variable transparent body is made of polydimethylsiloxane.

4. A camera module comprising:

a sensor;

a circuit board connected to the sensor; and

a zoom lens assembly facing the sensor, the zoom lens assembly comprising:

a lens barrel defining a through hole;

a plurality of optical lenses disposed in the through hole; and

a focusing member disposed between adjacent two of the plurality of optical lenses;

wherein the focusing member comprises a bottom plate, a cover plate, a piezoelectric element, a variable transparent body, and a conductive plate, the variable transparent body is disposed between the bottom plate and the cover plate, the piezoelectric element is disposed on a surface of the cover plate facing away from the variable transparent body, the piezoelectric element is staggered from the variable transparent body, so that when an electric voltage is applied to the piezoelectric element, an end of variable transparent body start to deform firstly, the conductive plate is connected to the piezoelectric element, the conductive plate defines an aperture, the bottom plate, the cover plate, and the variable transparent body are disposed in the aperture, the conductive plate and the lens barrel are integrally formed.

5. The camera module of claim 4, further comprising a sleeve and a conductive wiring, wherein the sleeve defines a first receiving hole, a first end of the conductive wiring is

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disposed in the first receiving hole, and a second end of the conductive wiring is disposed outside the first receiving hole,

the conductive plate is disposed within the first receiving hole and connected to the first end of the conductive wiring, and the circuit board is connected to the second end of the conductive wiring.

6. The camera module of claim 5, wherein the conductive wiring is formed on an inner surface or an outer surface of the sleeve by Direct Laser Sintering.

7. The camera module of claim 5, further comprising a base and an optical filter, wherein the base defines a second receiving hole, the optical filter is disposed in the second receiving hole facing the first receiving hole, and the base is arranged between the circuit board and the sleeve.

8. The camera module of claim 5, further comprising a reflecting member and an actuator, wherein the reflecting member is disposed on a side of the sleeve faces away from the circuit board, the actuator is connected to the reflecting member, and the actuator is configured to drive the reflecting member to move.

9. The camera module of claim 4, wherein the conductive plate is partially embedded in the lens barrel.

10. The camera module of claim 4, wherein the piezoelectric element is made of Lead Zirconate Titanate, and the variable transparent body is made of polydimethylsiloxane.

11. An electronic device comprising a camera module, the camera module comprising:

- a sensor;
- a circuit board connected to the sensor; and
- a zoom lens assembly facing the sensor, the zoom lens assembly comprising:
  - a lens barrel defining a through hole;
  - a plurality of optical lenses disposed in the through hole; and
  - a focusing member disposed between adjacent two of the plurality of optical lenses;

wherein the focusing member comprises a bottom plate, a cover plate, a piezoelectric element, a variable transparent body, and a conductive plate, the variable transparent body is disposed between the bottom plate and the cover plate, the

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piezoelectric element is disposed on a surface of the cover plate facing away from the variable transparent body, the piezoelectric element is staggered from the variable transparent body, so that when an electric voltage is applied to the piezoelectric element, an end of variable transparent body start to deform firstly, the conductive plate is connected to the piezoelectric element, the conductive plate defines an aperture, the bottom plate, the cover plate, and the variable transparent body are disposed in the aperture, the conductive plate and the lens barrel are integrally formed.

12. The electronic device of claim 11, further comprising a sleeve and a conductive wiring, wherein the sleeve defines a first receiving hole, a first end of the conductive wiring is disposed in the first receiving hole, and a second end of the conductive wiring is disposed outside the first receiving hole,

the conductive plate is disposed within the first receiving hole and connected to the first end of the conductive wiring, and the circuit board is connected to the second end of the conductive wiring.

13. The electronic device of claim 12, wherein the conductive wiring is formed on an inner surface or an outer surface of the sleeve by Direct Laser Sintering.

14. The electronic device of claim 12, further comprising a base and an optical filter, wherein the base defines a second receiving hole, the optical filter is disposed in the second receiving hole facing the first receiving hole, and the base is arranged between the circuit board and the sleeve.

15. The electronic device of claim 12, further comprising a reflecting member and an actuator, wherein the reflecting member is disposed on a side of the sleeve faces away from the circuit board, the actuator is connected to the reflecting member, and the actuator is configured to drive the reflecting member to move.

16. The electronic device of claim 11, wherein the conductive plate is partially embedded in the lens barrel.

17. The electronic device of claim 11, wherein the piezoelectric element is made of Lead Zirconate Titanate, and the variable transparent body is made of polydimethylsiloxane.

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